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Prior attempts to use standard “self report” or interview protocols to extract After Action Review (AAR) descriptions of emergency event decision making and problem solving strategies generated by participants are problematical. Cognitive psychological studies suggest that the resulting information often contains significant errors and omissions (Glaser et al., 1985; Besnard, 2000). These errors are not often recognized by participants who solved important problems in emergency situations and wish to give accurate reports on their solutions because the knowledge they are describing is largely automated and unconscious (Wheatley & Wegner, 2001). The problem is further complicated by the fact that experienced medical personnel mistakenly believe that their reports are complete and accurate and that they solved the problems they are describing in a conscious, willful, deliberate manner (Wegner, 2002). These reporting errors most likely increase in number and severity under time-pressure battlefield situations (Hunt & Joslyn, 2000). This research attempts to improve medical AAR with a novel combination of Cognitive Task Analysis (CTA) conducted while interviewees moulage simulators (Clark and Estes, 2002; Clark & Estes, 1996; Velmahos et al, 2002). Nine trauma surgeons, who have used Argyle-type shunts to repair femoral artery damage, were interviewed, in which they simply described (no CTA) the procedure. A full CTA was conducted with a tenth trauma surgeon with similar experience in the procedure. The interviews were coded and compared with a gold standard protocol. It was hypothesized that our protocol which employed a novel combination of medical Cognitive Task Analysis combined with the moulage of instruments and depictions of the femoral artery will more accurately capture the mix of automated and conscious decisions used to solve critical medical problems faced in battlefield situations. Analysis of the data indicated that (a) surgeons who gave unaided description of the protocol left out ± 70% of the critical steps in the procedure, (b) the heavy use of technology augmented the recall of steps, and the use of the CTA interview method increased the accuracy of the protocol when compared to the gold standard. The results suggest that significant consideration be given to adopting CTA for critical AAR’s and surgical skills training to increase accuracy and decrease errors.

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INTRODUCTION

This study was designed to test a novel approach to medical after action reviews (AAR) by employing a cognitive task analysis (CTA) interview protocol with surgeons who are asked to moulage a medical simulator while being interviewed. The research design (as revised in 1, 2, and 3 in Section 1 below) called for the interview of ten trauma surgeons who were either deployed in a Forward Surgical Team (FST) in Iraq or in residence at an urban trauma surgery service. Each surgeon was interviewed separately and asked to describe how to perform a shunt procedure under emergency conditions. Half of the surgeons described their surgical protocol as they manipulated the surgical instruments and viewed depictions of the anatomy surrounding the femoral artery. Of the ten surgeons interviewed, nine provided an unaided (no CTA) description of the shunt procedure, and one was interviewed using CTA methods. A "gold standard" protocol was developed from the interview data, which was reviewed and corrected by an independent vascular surgeon. The accuracy and completeness of each surgeon's interview data was compared to the gold standard to determine the gain or loss of AAR fidelity due to CTA use with and without simulators.

BODY

In this part of our report we review the results of the study in relation to the Statement of Work (SOW) approved in our proposal.

1) **Work with designated Army POC to identify and schedule interviews with three medical personnel who separately experienced and solved an important medical problem.**

   We determined that we could not limit our study to three surgeons because of analysis problems and so sought and received IRB permission to extend the number of subjects from three surgeons to a minimum of eight and a maximum of 10. At Dr. Pugh's suggestion and because of difficulty securing the participation of Army surgeons, we extended invitations to trauma surgeons in an urban ER that serves as a training center for military surgeons. During the IRB Continuing Review process in August, 2006, our study was re-categorized as "exempt" human subject research. In all, 11 surgeons participated in the study: Nine surgeons were interviewed without CTA; one surgeon was interviewed with CTA; and one surgeon reviewed and corrected a gold standard protocol produced from the interview data captured from the other 10 surgeons.

2) **Develop an interview protocol based on Cognitive Task Analysis (CTA) and arrange for the use of medical simulators to be used during the interviews**.

   Starting at the beginning of the project, the research team developed a CTA interview protocol which was reviewed, tested in the interview with a benchmark Army trauma surgeon who had experience working in an early Forward Surgical Team (FST) in Iraq and this protocol was analyzed by the research team. This version of the CTA interview protocol is attached as *Appendix A* at the end of this report.

Problems:
The Army surgeons we consulted initially advised us to focus our interviews on the use of Argyle-type shunts because of the number of traumatic leg injuries in Iraq. This novel use of the shunts has apparently saved many soldiers from amputation. Yet after we scheduled our interviews we learned that there is currently no available simulator that allows surgeons to moulage the area surrounding the femoral artery to demonstrate their technique with the shunts. Our COR, Dr. Pugh, advised us to substitute a tray of the surgical instruments used during the surgery and high resolution color images of exposed femoral arteries for the surgeons who are randomly assigned to that condition in our study.

3) **Conduct the CTA interviews with each of the participants separately, keeping a video and audio record of the result as described in the methods section and in the approximate sequence listed in Figure 1 (in the proposal).**

All interviews have been completed, and video and audio records have been made of all interviews as specified in our SOW according to the sequence listed in our proposal.

Problems: During the course of this study we have experienced constant and significant difficulties securing the participation of trauma surgeons with battlefield experience. Most Army trauma surgeons are fully deployed and while most of those contacted were supportive and willing to participate, few had the time. Our COR, Dr. Pugh, advised us to extend our invitation to include urban trauma surgeons in the study. With the considerable help of Dr. Maura Sullivan of the Keck School of Medicine at USC, surgeons were recruited from Los Angeles County USC Medical Center and the surgery department of the USC Keck School of Medicine, as these surgeons constantly handle injuries that are very similar to those that occur in battlefield situations. The delay caused by our initial difficulty in recruiting surgeons led us to request a no cost extension in our study. The study, originally scheduled for completion on 9/30/2006, is now complete with the filing of this report.

4) **Summarize each interview as a procedure listing the types of information gathered.**

All ten interviews collected in the past year have been completed, transcribed and each was formatted as a procedure for review and correction by each surgeon, as specified in our proposal. All surgeons reviewed and corrected, as necessary, and returned the protocols. One of the formatted and corrected protocols generated by an Army trauma surgeon who is scheduled for his second tour of duty in Iraq is attached as Appendix B to serve as an example of the outcome of this stage in the SOW.

The revised protocols from each surgeon were combined to create a “gold standard” protocol, which was independently reviewed and revised by a professor of vascular surgery at the USC Keck School of Medicine. The gold standard protocol is attached as Appendix C.

5) **Write and submit a final report at the end of the project that answers the following questions: a) what important medical event(s) was/were encountered? b) What aspects of their prior training helped prepare the medical experts for the event and what additional preparation would help new medical personnel to deal more effectively with**

similar events?; c) What solution(s) were developed in the field that should be included in future training? d) A description of the CTA and simulator process overview and evaluation; and e) how can we leverage the field solutions for the development of new training that uses more advanced medical simulation technology?

Final Report
W81XWH-04-C-0093
The Use of Cognitive Task Analysis and Simulators for After
Action Review of Medical Events in Iraq

What important medical event(s) was/were encountered?

The delivery of health care on the battlefield is through an echelon system with escalating levels of care. The first of five echelons is the battalion aid station, which gives soldiers bandages, fluid resuscitation, and tourniquets for uncontrolled bleeding.[1] In current conflicts, especially in Iraq, forward surgical teams (FST) co-locate with a Level 2 echelon, normally a brigade aid station one terrain feature away from the forward edge of the battle area. FSTs provide surgical resuscitative care for injuries that would not survive a prolonged evacuation process. Typically, an FST consists of three general surgeons, one orthopedic surgeon, and approximately 16 nurses and technicians.

When an FST receives a patient with femoral artery disruption, the medical team is faced with several treatment options. The first option is definitive vascular repair; however, the battlefield conditions and the mission of the FST generally require that surgeons either ligate the vessel and evacuate the patient to the next level of care, or shunt the vessel to stop the bleeding and restore blood flow to the extremity. Whether the patient can be evacuated in a timely manner depends on the evacuation capabilities in the battlefield and the level of activity at the Level 3 echelon. Thus, the most viable option in an FST is to use a shunt as the highest level of care for these patients.

Army surgeons constantly work to improve their level of technology and training sophistication in the deployed environment. Toward that end, surgeons undergo significant training prior to deployment on how to assess, manage, and treat severely traumatized patients. One component of this training includes situational planning and learning how to work with limited equipment and severe time constraints and battlefield conditions during treatment of patients with serious vascular injuries to the extremities, in which poor workmanship often results in morbidity or mortality. Situational planning and training for these conditions includes the use of Argyle-type shunts to restore temporary blood flow as a result of damage to the femoral artery.

The Army has adopted the After Action Review (AAR) as the primary method for providing military historical research for training development and performance feedback during training (Morrison & Melliza, 1999). During an interactive discussion, three questions are addressed: (1) “What happened?” (2) “Why did it happen?” and (3) “How can units improve their

[1] Information provided by Surgeon 1 with FST experience in Iraq. Additional echelons include Level 3, a division level combat surgical hospital. Level 4 is a fixed facility outside of the United States, and Level 5 is a fixed facility in the United States.

performance?" As a collective self-examination, however, AARs largely rely on the self-report of discussion participants, and is, therefore, heavily memory-dependent.

Clark et al. (2007) estimate that self-reports capture only 30% of important details about surgical procedures. This problem is caused by automated and unconscious knowledge that cannot be self-reported (Clark & Estes, 1996). Self-reports and unaided interviews result in inaccurate and incomplete knowledge captured in After Action Reviews (AAR), and when transferred by faulty training result in negative consequences. As a result, mistakes in training are learned by new surgeons and must be corrected by trial and error.

Cognitive Task Analysis (CTA) uses semi-structured interviews to identify the knowledge, goals, strategies, and decisions that underlie observable task performance (CTA Resource, 2006). The use of CTA methods has been demonstrated to provide a 12% increase (Chao & Salvendy, 1994) and a 40% increase (Clark & Estes, 1996) in the amount of information captured from experts during performance of a task. In addition, in this study, it was thought that the moulage of simulators during CTA might increase the accuracy of the protocols by stimulating the recall of critical surgical steps (Pugh & Clark, 2006).

Our study attempts to improve AAR by examining whether the combination of Cognitive Task Analysis (CTA) methods and simulations will more accurately capture the automated and conscious decisions surgeons make as they describe the procedure for inserting a femoral artery shunt to restore blood flow to a damaged extremity under extreme conditions. We hypothesized that (1) surgeons who give unaided descriptions of the procedure will omit about 70% of the critical surgical steps, when compared with a gold standard protocol; (2) the use of simulators during self-report will increase the completeness and accuracy of protocols, by stimulating recall of critical surgical steps; and (3) cognitive task analysis interviews will increase the accuracy and completeness of protocols by more than 12% and less than 40%.

Method

Nine trauma surgeons, who have used Argyle-type shunts to repair femoral artery damage in an urban environment, were interviewed, in which they simply described (no CTA) the procedure. Follow-up questions were asked to clarify statements made in the unaided section of the interview. Each surgeon was interviewed separately and asked to describe how to perform the shunt procedure under emergency conditions. Half of the surgeons described their surgical protocol as they manipulated a set of surgical instruments and viewed depictions of the anatomy surrounding the femoral artery. The remaining surgeons comprised the "no technology" condition.

A full CTA was conducted with a tenth trauma surgeon, who had recently returned from a deployment in a Forward Surgical Team in Iraq. A trained interviewer, who was not a surgeon, conducted the semi-structured interview using the protocol attached as Appendix A, which consists of a series of questions pertaining to (1) Conditions (indications and contraindications for performing the procedures) (2) Processes (who does what, when, and where); (3) Steps (action steps and decision steps accompanied by alternatives and the criteria for deciding); (4) Standards (time and quality); (5) Equipment (instruments); and Reasons (principles of science, i.e., why do this, and not that); and (6) Concepts (names, symbols, or events that a person would need to know to perform the procedure).

All interviews were recorded with audio and video. The interviews were transcribed verbatim, and were coded using the coding scheme attached as Appendix D that related to the six lines of questioning outlined previously. Two coders worked independently to code the transcripts, and then met to compare the results and resolve the discrepancies. An inter-rater reliability of .87 was achieved in the coding.

A protocol of the each surgeon's description of the procedure was developed from the coded transcripts and reviewed for accuracy by the other coder. The surgeons were then given the opportunity to review and correct the protocol developed from their transcribed interview. The surgeons' corrected protocols were aggregated to create a preliminary "gold standard" protocol. An independent vascular surgeon, who was also a member of the faculty at a leading medical school, reviewed and corrected the preliminary protocol, which then became the final gold standard.

As the final step in data gathering, the accuracy and completeness of each surgeon's interview data, represented by the statements contained in the protocol, were compared to the gold standard to determine the gain or loss of AAR fidelity due to CTA use with and without simulators. Surgeons' protocols were compared and analyzed prior to being corrected (Round 1), and after review and correction (Round 2). Additional data included the level of experience, measured by the surgeons' report of the number of shunt procedures performed, and a review of the video tape record to assign the level of technology interaction during the interview, for those surgeons in the technology condition. A rating scale was developed as follows: "Minimal" refers to technology verbally, visually, or pointing; "Occasional" = touches technology occasionally; Heavy = uses technology to demonstrate procedure.

Results

Hypothesis 1: Surgeons who give unaided description of the protocol will omit ± 70% of the critical steps in the surgical procedure, when compared with the gold standard protocol.

The total percentage of agreement between surgeons' description of the shunt procedural steps and the gold standard protocol in the unaided interview condition were 25.00% in Round 1 and 6.25% in Round 2 for a total of 31.25% agreement. Thus, surgeons omitted 68.75 % of the standard procedural steps in support of Hypothesis 1 (see Figure 1).

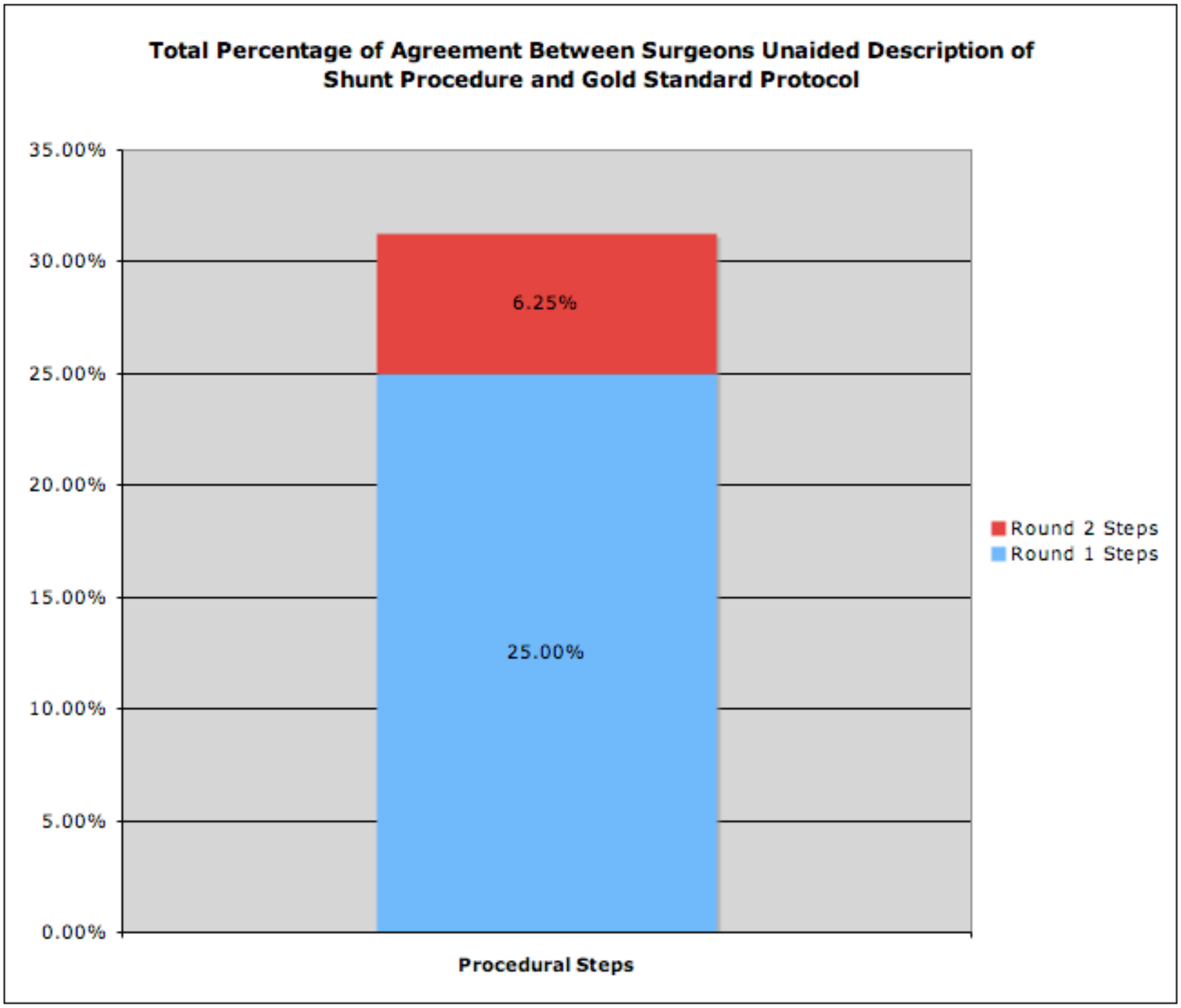

Figure 1

As a further exploration, it was also hypothesized that the completeness of unaided, self-reported protocol information will vary within different segments of the surgical protocol. As shown by Figure 2, the percentage of agreement with the gold standard protocol varied within the surgical protocol with Contraindications (13.89%), Indications (21.53%), Steps (31.25%), and Equipment (50.43%).

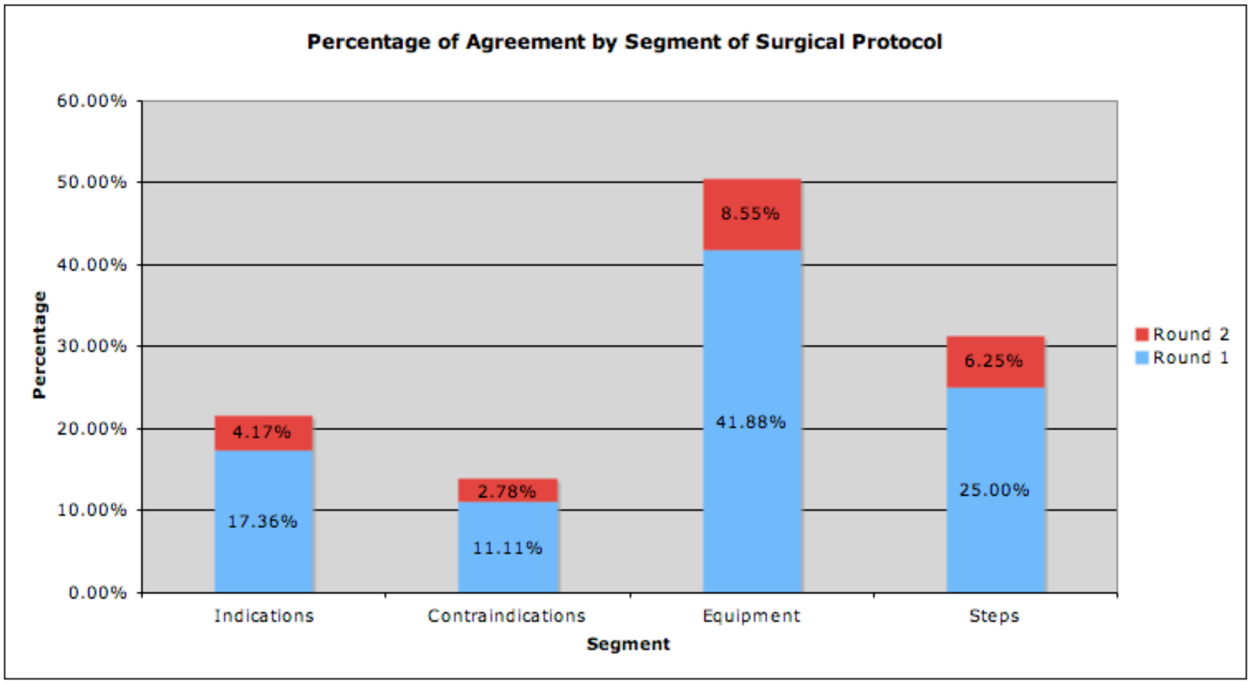

Figure 2

Hypothesis 2: The use of simulators during self-report will increase the completeness and accuracy of protocols by stimulating recall of critical surgical steps.

Surgeons in the unaided condition (no CTA) were randomly assigned to two conditions – recall aided by technology (presence of instruments and visuals) and recall without the presence of technology. The video records of the unaided (no CTA) Surgeons in the technology condition were reviewed to rate the level of interactivity with the technology. The following rating scale was used: "Minimal" refers to technology verbally, visually, or pointing; "Occasional" = touches technology occasionally; Heavy = uses technology to demonstrate procedure. Figure 3 shows the percentage of agreement of unaided (no CTA) surgeons' description of procedural steps by the level of interaction with technology.

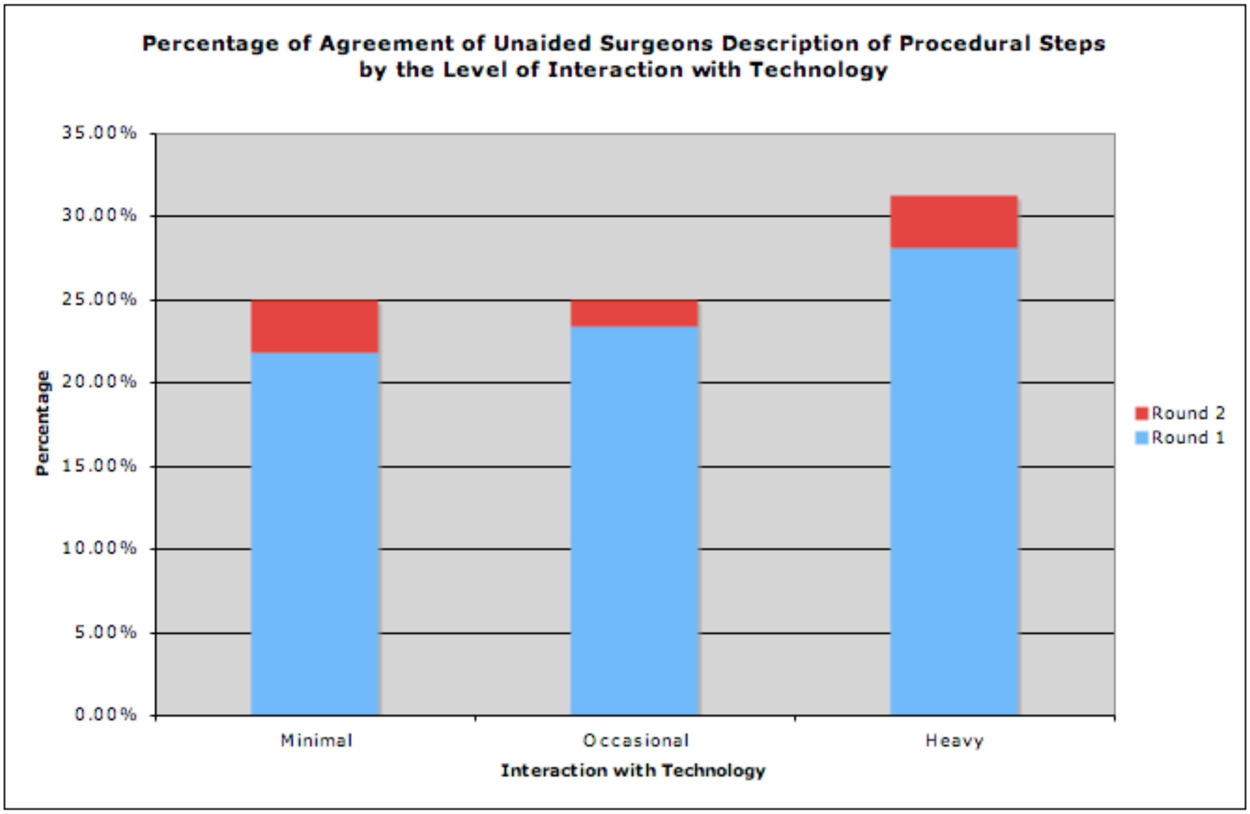

Figure 3

Figure 3 indicates that there is no difference between the Minimal and Occasional use of technology in the agreement unaided surgeons recall when compared with the gold standard. However, the heavy use of technology increased the level of agreement in both Round 1 and Round 2. These data would appear to support the hypothesis that the increased use of technology augments surgeons' description of the procedural steps.

Hypothesis 3: A cognitive task analysis interview will increase the accuracy and completeness of protocols by more than 12% and less than 40%

As shown in Figure 4, a comparison between the no CTA and CTA conditions demonstrates the increase in the percentage of agreement between aided and unaided descriptions of the shunt procedure when compared with the gold standard. The results show that the total percentage of agreement with CTA is 68.75% compared with 31.25% without CTA in support of Hypothesis 3.

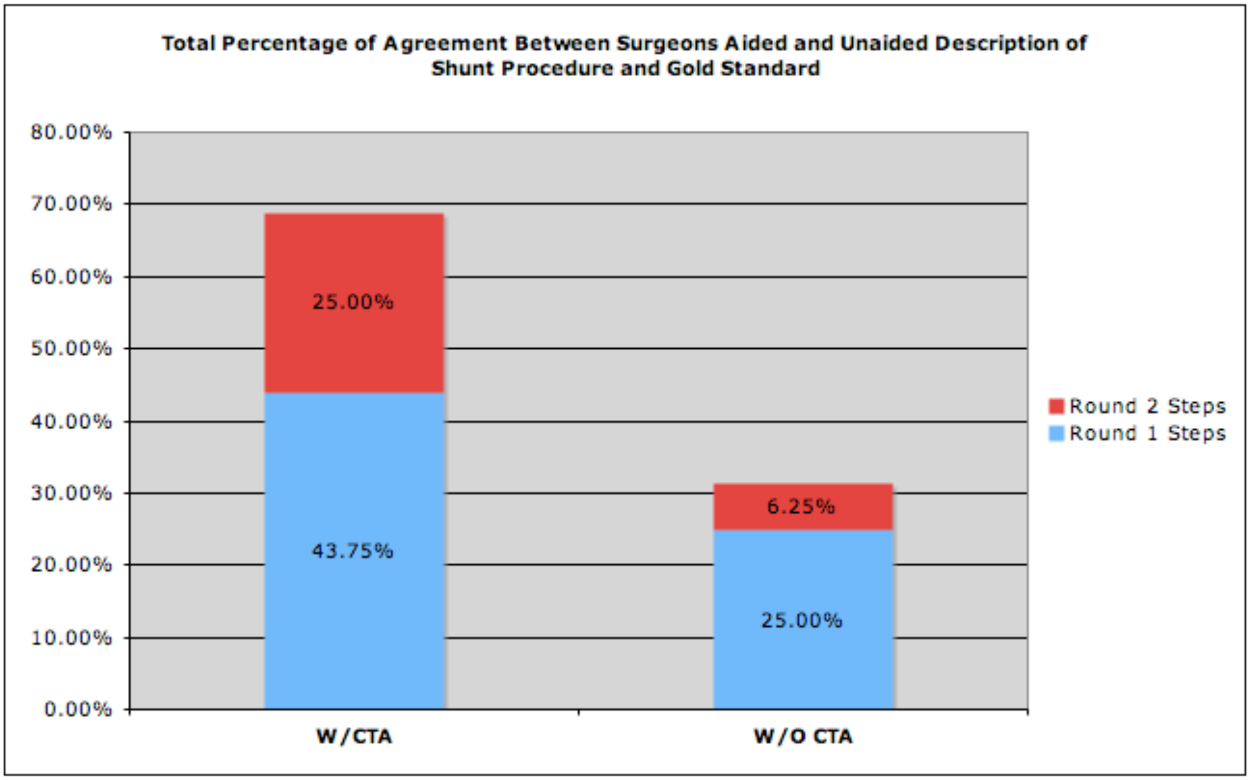

Figure 4

In sum, the study sought to replicate the AAR environment that relies on self-report discussions of events through the unaided (no CTA) condition, in which the accuracy and completeness of the descriptions of surgical procedures are memory-dependent. Although a sufficient number of surgeons previously deployed in the Iraq theatre of operations were not available for the study, or the use of a high-fidelity simulator, the results demonstrate that when Cognitive Task Analysis methods are applied, both the accuracy and completeness of surgeons' descriptions increase. These results hold promise for the use of CTA in combination with AARs to enhance training effectiveness and efficiency, in contrast with the use of AARs alone.

What aspects of their prior training helped prepare the medical experts for the event and what additional preparation would help new medical personnel to deal more effectively with similar events?

Through the Defense Medical Readiness Training Institute (DMRTI; 2007), the Army responds to the training needs of surgeons and other health care providers to maintain critical life saving skills necessary for changing battlefield environments. For example, the Emergency War Surgery Course (EWSC) was developed in response to 1991 Gulf War reports that surgeons needed increased training and experience in trauma surgery. To the extent that such courses are based on self-report AARs only, they may contain incomplete or inaccurate information, whereas training based on information elicited by CTA methods is more likely to replicate the required level of performance.

What solution(s) were developed in the field that should be included in future training?

The results of the study suggest that consideration be given to adopting CTA for critical AARs and surgical skills training to increase accuracy and decrease errors, in particular, errors in judgment. Further, it may be possible to use "gold standard" protocols developed from CTA's for surgical skills assessment. And finally, CTA's of surgical skills could be used to enhance simulator-based training. Further studies should be conducted that compare CTA-based protocols for training with the traditional Halsteadian "see one, do one, teach one" pedagogy.

A description of the CTA and simulator process overview and evaluation
See Appendix A.

How can we leverage the field solutions for the development of new training that uses more advanced medical simulation technology?

The application of CTA methods with subject matter experts (SME) produce representations of expert performance in increasingly complex and difficult settings, which, in turn, can be developed into simulations that provide efficient and effective practice of surgical skills acquired during training.

There is considerable empirical evidence that expertise in medicine cannot be achieved through extended experience alone; rather expert performance continues to improve through additional experience coupled with deliberate practice (Ericsson, 2004). In contrast with the acquisition of everyday skills, which become automated and outside of our conscious control, expert performers engage in deliberate practice by continuing to seek out training situations in which goals that are representative of expertise extend beyond the existing level of performance, and thus require increased conscious control and performance monitoring.

In addition, studies show that, in surgical performance, as the number of procedures performed increases, the time to complete the surgeries and the frequency of injuries decreases (Ericsson, 2004). Because the experience of performing the procedure on the first few patients provides immediate and intensive feedback, skill acquisition is rapid. Simulators provide an environment for surgeons to repeatedly and deliberately practice new surgical skills while receiving immediate and corrective feedback based on desired expert performance captured by the CTA enterprise.

<u>LIST OF PERSONNEL RECEIVING PAY FROM THE RESEARCH EFFORT:</u>

Richard E. Clark, Ed.D.
Richard S. Brown, Ph.D.
David F. Feldon, Ph.D.
Kenneth A. Yates, Ed.D.
Donna Darling

KEY RESEARCH ACCOMPLISHMENTS

- The development of a surgical cognitive task analysis protocol (See Appendix A)
- The development of Procedure for the Use of a Shunt for Lower Extremity Vascular Disruption (see Appendix C).
- Research data indicating that (a) Surgeons who gave unaided description of the protocol left out ± 70% of the critical steps in the procedure, (b) the heavy use of technology augmented the recall of steps, and (c) the use of the CTA interview method increased the accuracy of the protocol when compared to the gold standard.
- The results suggest that significant consideration be given to adopting CTA for critical AARs and surgical skills training to increase accuracy and decrease errors.

REPORTABLE OUTCOMES

- The development of a surgical cognitive task analysis protocol (See Appendix A)
- The development of trauma surgeon CTA's for the use of Argyle Shunts (See example in Appendix B and the "gold standard" CTA in Appendix C)
- Presentations at professional conferences related to this study:

    - Clark, R. E. (March 2007). The Use of Cognitive Task Analysis and Simulators for After Action Review of Medical Events in Iraq. Presentation to TATRC Product Line Review Conference. San Antonio, Texas, March 7, 2007.

    - Feldon, D. & Clark, R. E. (June 2006). Instructional implications of task analysis for improving experts self report. Presentation to the European Association for Learning and Instruction. Leuven, Belgium, June 21, 2006.

    - Pugh, C. & Clark, R. E. (April, 2006) Use of Cognitive Task Analysis and Simulators to Reduce Errors in Surgical Training. Paper presented in a symposium at the annual meeting of the American Educational Research Association in San Francisco, CA, April 10, 2006.

    - Clark, R.E. (September 2005). Assessment insights from the use of cognitive task analysis to study expertise development. Invited address to the 2005 CRESST conference. Los Angeles, California, September 8, 2005.

    - Clark, R. E. & Pugh, C. (July 2005). Use of cognitive task analysis in surgical simulations. Invited address to the Office of Naval Research Conference titled "Metrics for evaluating performance in simulations". Redondo Beach, California, July 12, 2005.

    - Clark, R. E. & Feldon, D. (February 2005). Cognitive task analysis and simulators for after action reviews of medical events. Invited address to the annual meeting of the Telemedicine and Advanced Technology Research Center (TATRC), Marina del Rey, California, February 15, 2005.

CONCLUSIONS

The study sought to replicate the AAR environment, in which the accuracy and completeness of the descriptions of surgical procedures are memory-dependent, to demonstrate that when Cognitive Task Analysis methods are applied, both the accuracy and completeness of surgeons' descriptions increase. These results hold promise for the use of CTA in combination with AARs to enhance training effectiveness and efficiency, in contrast with the use of AARs alone.

The application of CTA methods with subject matter experts (SME) produce representations of expert performance in increasingly complex and difficult settings, which, in turn, can be developed into simulations that provide efficient and effective practice of surgical skills acquired during training. Simulators provide an environment for surgeons to repeatedly and deliberately practice new surgical skills while receiving immediate and corrective feedback, based on desired expert performance captured by the CTA enterprise. Further research should focus on comparing CTA –based training that integrates simulator-based practice with the traditional "see one, do one, teach one" pedagogy.

Incorporating "gold standard" CTAs as the basis for assessment of surgical skills should also be examined.

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APPENDIX A: Surgical CTA Protocol

Developed for TATRC Grant Award # **W81XWH-04-C-0093**
Richard E. Clark, Ed.D.

1. Establish general context for use of procedure, general indications and contraindications for use and any relevant history (see "Questions to be asked…" below, items 1-3).

2. Ask for a sequential explanation of the process. Emphasize that instructions should be given as they would to an intermediate medical student, and request that steps be described as specifically and completely as possible, including decisions that must be made, cues that must be attended to, etc. Remind the subject to use ordinal descriptors as frequently as possible (e.g. "First, do step 1. Second do step 2. Next, do step 3…"). Questions/clarifications should only be asked of the subject if the words used or pronoun-antecedent relationships are not clear. Ask also about the decisions that must be made and the criteria for choosing between the various alternatives when decisions are made (see "Questions to be asked…", below, items 4 and 5)

3. Recite the sequence back to the subject – that is, paraphrase what you hear them say. Ask for corrections and clarifications.

4. Ask the subject if the sequence after the corrections and clarifications is sufficient to allow someone to complete the task successfully (see "Questions to be asked…" below, items 6-7).

5. Take a break. Compile notes into a single, step by step, action and decision procedure.

6. Ask the subject to listen to you talk through the procedure as if someone was performing the procedure in a hypothetical situation. Instruct him to interrupt, clarify, or correct if anything said is inconsistent with how he/she would perform the procedure.

7. Review the corrected procedure with subject. At each identified decision point, ask for all relevant cues (see "Questions to be asked…" below, items 4-5). Verify by rephrasing as a question (e.g. "So, in order to make this decision, I only need to look at these two things?").

8. In preparation for a follow-up meeting, compile the written CTA document and send to the subject. Ask him/her to make any changes that are necessary to correct the accuracy of the CTA using the "track changes" function in Microsoft Word or to print a copy and bring handwritten notes for changes to the follow-up meeting.

9. At follow-up meeting, discuss all changes and finalize the CTA description. Explain to subject that when he is asked to review others' CTA documents, his role is to determine whether or not the task can be successfully completed using the steps presented. He should neither assume that something unstated is known nor that the CTA should exactly match his personal procedure. He should also edit any steps that are unnecessary. The

emphasis should be on whether or not the CTA document to be reviewed is viable and efficient to complete the task as written. Any changes that the subject wants to make should be made in the same manner as the edits to his own document.

Questions to be asked during the interview protocol

1) What happened? What were the problems being solved and the medical goal of this event? The objective of this question is to collect the expert's overview description of the "what, where, when, who, why" the event happened. In addition, background information on the precursors, context, preparedness, important and unexpected aspects of the event are collected as well as the expert's view of the goal to be achieved.

2) What conditions must be present to start the task? Here the goal is to collect information about the medical "conditions" or "indications and counter indications" that would permit medical personnel who have not experienced this event to know when it has occurred and how to identify it unambiguously. Any tests, observations or measurements that must be made are collected and described.

3) What is the reason for the unique or unexpected nature of this event? The goal here is to collect background information on why this event was perceived as unexpected or important. The interviewer usually asks what aspect of prior training or education prepared the expert for this event –and what might prepare future surgeons more adequately to deal with it.

4) What actions and decisions must be implemented to complete the task? What alternatives must be considered and what criteria must be used to decide among the alternatives? This question is the core of a CTA interview. The expert is asked to describe, in a step-by-step fashion, everything that must be done to diagnose and treat the problem being investigated. This is often the second question that is asked (after #1, "what happened"). The answers to questions # 2 and 3 most often turn up as the expert describes the sequence they follow(ed) to diagnose and treat. As the sequence unfolds, the interviewer often interrupts with questions about the actions being described such as "Can you demonstrate on the simulator what you are describing?", or "Why did you do that?", or "What alternatives did you consider and what criteria did you use to make that decision?" and "What would lead you to make a different decision with another patient? Could you demonstrate a different set of constraints for that decision on the simulator?" The key issue in a CTA is to capture all of the many complex decisions that must be made, the alternatives that must be considered before a decision is reached and the essential criteria for choosing between the alternatives. It is knowing when and how to make decisions that are most often the source of errors in medical training since experts tend to automate their decision making. While experienced experts make very rapid and accurate decisions, they cannot observe what goes on in their mind as they decide and so often fail to report decisions or the range of alternatives they considered and rejected. This information contributes to training that is often very accurate when it depicts the observable actions that subject matter experts (SME) use to solve problems but unobservable decisions are often ignored or distorted. The goal of this aspect of the CTA is to produce an accurate, step by step description of the most efficient and effective way to reach the medical goal and sub-goals of the task.

5) What concepts, processes or principle knowledge is required to adjust this task to fit novel conditions? As the expert describes actions and decisions in response to question #4, the CTA interviewer occasionally interrupts and asks for details about three types of knowledge. A) Concepts -- An explanation of the special medical or scientific terms used by the expert. The interviewer asks for definitions and identifiable examples. Examples are collected (and scanned or otherwise stored on a computer for later use as illustrations in the CTA). Concepts are the type of knowledge that supports accurate classification of all aspects of the problem and solution. B) Processes -- An explanation of how something important to the goal works, stage by stage – such as a disease progression or an organ system. Processes support clear understanding of the wider context of the systems involved in the problem and solution and help experts generate more adequate solutions to problems; and C) Principles - Essentially the "science" of the phenomenon being described in the form of variable cause and effect statements. Principles help identify and explain causes, solutions and the adjustment of procedures to accommodate highly important incidents related to the problem being studied. These three types of knowledge will eventually be reorganized and presented as the body of conceptual and scientific knowledge that will support the diagnosing and treating of the problem and the editing of established treatments to accommodate unusual cases.

6) What equipment and materials are required? The objective with this question is to determine if any unusual medical equipment or supplies, not usually available in the context where this problem might occur, need to be provided in order to effectively diagnose and treat the problem effectively. Descriptions of equipment are collected and scanned or stored on a computer for later use in the CTA report.

7) What performance standards must be achieved? (E.g. time, accuracy). All essential quantity and quality standards for the diagnosis and treatment of the problem must be identified so that they can be described in assessment instruments and for eventual training media and materials.

APPENDIX B:

Cognitive Task Analysis:
Surgical Use Of Argyle Shunt For Lower Extremity Vascular Disruption

Surgeon D
Procedure Description: Lines 39 - 91[2]

Task Analyst: Richard Clark, Ed.D.
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August 16, 2006
Final Draft

Objective: Restore viability of the femoral artery (85)

Conditions:

Indications:

- Temporary shunting for orthopedic procedures (79)
- Combined vascular orthopedic injuries (94)
- Temporary restoration of blood flow to stabilize Pt (112, 126))
- Unavailability of vascular expertise to repair the vessel (120)

Contraindications:

Equipment:

- Surgical tray (39)
- Vessel loops (42)
- Heparin saline (47) and systemic (55)
- Right angle (42) and other (e.g. bulldog) vascular clamps (48)
- Fogarty catheter (51) (Size 3 or 4) (134)
- Silk tie (e.g., 2-0, 3-0) (76)
- Doppler (83)

Standard:

An extremity that is: (85)

- Warm
- Perfused
- Capillary refill

[2] The first part of this appendix represents a reformatted version of the interview data provided by Surgeon D. The second part of the appendix is a copy of the exact interview transcript where all "lines" are numbered. References to "lines" in the first part of the appendix indicates the location in the transcript of the CTA interview where the information in that section can be found. The interview transcript is reformatted to reflect the correct sequence and rationale for each stage in the shunt protocol since surgeons tend to jump around as they narrate the procedure they use.

- Pink
- Has a flow detectable by Doppler

Task List:

1. Control proximal and distal blood flow (39)
2. Prepare the vessel for the shunt (45)
3. Place the shunt in the artery (57)
4. Secure the shunt (75) and evaluate distal perfusion (82)

Task 1: Control proximal and distal blood flow (39)

Goal: Control proximal and distal blood flow (39), remove obstructions to flow (50), and inhibit clotting locally (47, 54) and, if appropriate, systemically (55).

Step 1.1: Control hemorrhage digitally with compression of the finger or hand (39)

Step 1.2: Dissect down around the finger or hand and expose the proximal and distal femoral artery (40)

Step 1.3: Clamp the proximal artery with a vascular or bull dog clamp and place a vessel loop (42) on the artery

Step 1.4: Repeat Step 1.3 distally (43)

Step 1.5: Repeat Step 1.3 for other side branches (44)

Step 1.6: Pull up on proximal and distal vessel loops, remove finger, and examine (44)

Step 1.7A: Decide if blood flow from proximal and distal artery has stopped (45)

IF blood flow has stopped, THEN go to Task 2 (45)

IF blood flow has not stopped, THEN re-evaluate clamps and search for additional side branches

Task 2: Prepare the vessel for the shunt (45)

Goal: Confirm antegrade flow of the proximal artery (46) and back bleeding of the distal artery (49); remove any obstructions to blood flow (53); inhibit clotting in the vessel (47, 54)

Step 2.1A: Decide if there is brisk antegrade flow from the proximal artery (46)

IF there is brisk antegrade flow, THEN go to Step 2.2 (47)

IF the antegrade flow is less than brisk, THEN pass fogarty catheters.

Step 2.2 Flush the proximal artery with Heparin saline (47)

Step 2.3: Place a vascular clamp on the artery (48)

Step 2.4: Examine the distal artery for back bleeding (49)

Step 2.5: Pass a Fogarty catheter in the distal artery and reexamine for back bleeding (50)

Step 2.6A: Decide if there is adequate back bleeding distally (52)

IF there is adequate back bleed and no clot is returned (149), THEN go to Step 2.7

IF there is not adequate back bleed and/or clot is returned (149), THEN repeat Step 2.5 (149)

IF there is not adequate back bleed and no clot is returned (150), THEN go to Step 2.7

Step 2.7: Flush the distal artery with Heparin saline (54)

Step 2.8: Place a clamp on the distal artery (54)

Step 2.9A: Decide whether to give Heparin systemically (55)

IF it is an isolated injury, THEN give 5,000 units of Heparin systemically (55)

IF there are associated injuries, THEN do not give Heparin systemically (56)

Task 3: Place the shunt in the artery (57)

Step 3.1: Examine the ends of the artery (57)

Step 3.2: Without debriding (57) and leaving the edges ragged (58), place the shunt near the proximal artery (58)

Step 3.3: Take the clamp off (58) and place the shunt in the proximal artery (59) about 3 to 4 centimeters (62)

Step 3.4: Secure the shunt with the vessel loop (60) by pulling up

Step 3.5A: Decide if there is brisk bleeding out of the shunt (61)

IF there is brisk bleeding, THEN go to Step 3.6 (63)

IF there is not brisk bleeding, THEN re-evaluate the proximal artery (step 2.1)

Step 3.6: Clamp the shunt to stop the blood flow (63)

Step 3.7: Measure the length of the shunt in relation to the remaining artery (64)

Step 3.8A: Decide if the shunt needs cutting

IF the defect is huge, and the shunt just barely fits into both (64), THEN will need longer shunt or another type of shunt, or may not be able to shunt and may need immediate definitive repair.

IF there is little defect, THEN cut the shunt as necessary, so that it will fit 3 to 4 centimeters into the distal artery (66)

Standard: The ends must be cut square (176) with no sharp edges (178), to avoid internal disruption as it is placed in the distal artery (69)

Step 3.9: Back bleed the distal artery (71)

Step 3.10: Place the shunt in the distal artery (72)

Step 3.11: Secure the shunt with the vessel loop (72)

Task 4: Secure the shunt (75) and evaluate distal perfusion (82)

Step 4.1: Tie the vessel around the shunt (76) proximally and distally (75)

Step 4.2: Tie the shunt to the vessel (78) proximally and distally (80)

Step 4.3: Observe visual and tactile distal perfusion (82)

Step 4.4: Assess blood flow with Doppler (83)

End

Interview 10D May 17
RC=Richard Clark
S=Surgeon
K=Ken

RC: We've got an IRB form, did anybody show it to you? I don't remember if we sent it to you are not. It's got a description of the study if you want to see it and I hope you take it away. You keep one and I'll keep the one you sign. We're asking to videotape this but the videotape won't be published; we're just going to use it for data collection. If we want to do anything else with it, we will contact you to get a separate permission from you. I'm also audio taping because we always want a backup.

What this study is about is the use of a.., we're just trying to collect a protocol. Have you ever done one? How many do you think you might have done?

S: Shunts period or shunts of the femoral artery?

RC: Shunts of the femoral artery. Let's start there and then just do shunts period.

S: Shunts of the artery, probably 2 or 3. Shunts total probably a dozen.

RC: In the 2 or 3, how long?

S: 4 years.

RC: The other shunts, what area?

S: About 50

RC: What we're trying to do, oh, the other areas you've done shunts?

S: Mesenteric arteries, iliac arteries, clavion artery, brachial artery, popliteal artery.

RC: Just about everything.

S: Bunch, yeah.

RC: I'm going to shut up after asking a few questions at least for the first part of this. I would like for you to describe sir, from the beginning, step by step, how to put a shunt into a brachial or into a femoral artery and describe it to me the way you'd describe it to somebody who was going to learn how to do it. Somebody who had enough preparation that it would be reasonable for you to tell them how to do it. It's not a common procedure as I understand it.

S: Right, correct.

RC: But it is something that a trauma surgeon would at some point. So if you'd do it in that regard, try to do it step by step, what do I do first, second, third, fourth.

S: Okay. Does it matter what the mechanism, gunshot, stab wound, do you care?

RC: No, if it matters to you or it would determine when or where or how, then describe it, but other than that, no.

S: I would control hemorrhage digitally with compression of the finger or hand, make an incision over the femoral artery. Next I would dissect down around the finger for controlling the hemorrhage and then expose the proximal and distal femoral artery. Once those were exposed I would get proximal control with a right angle and a vessel loop to get proximal control of the femoral artery. Do the same thing distally, right angle and a vessel loop, just to have those areas controlled. I control it on the other side branches that might be feeding. At that point I would pull up on both vessel loops and take my finger off to see if we had it controlled. If we had it controlled, then I would see if I had antigrade flow from the proximal artery that bleeds briskly. Then I would be done with the proximal artery. I would flush the proximal artery with Heparin saline and place a vascular clamp on that proximal artery.

Next I would look at the distal artery so what the back bleeding is like from there. If it’s brisk back bleeding I would probably still pass a Fogarty catheter one time just to make sure there’s no obvious clot. And if there’s no back bleeding I pass a Fogarty catheter to retrieve any clot and see what kind of back bleeding I get.

At this point, if it was an isolated femoral artery injury, I’m sorry after I pass a Fogarty in the distal artery I would flush that with Heparin saline as well and place a clamp on that. Now that I’ve got proximal distal controls, if it’s an isolated injury I would give 5,000 units of Heparin systemically. If there associated injuries, I would skip that step, I won’t Heparnize.

Now I look at the 2 ends of my artery. Since I’m going to shunt I would not debride the edges at all. I would leave the edges ragged. I would place the shunt near the proximal artery. Take the clamp off, place the shunt in the proximal artery and usually you can hold that shunt in place temporarily with the vessel that you had before. You kind of pull up on the vessel loop, kind of go down around the shunt. At that point, I should see pretty brisk bleeding out of the shunt. Your plugged in proximers come out pretty briskly. I would take it about 3 or 4 centimeters into the proximal artery. If I get brisk bleeding, I would clamp the shunt so it stops bleeding. And then I would measure my length of the shunt in relation to the remaining artery I have. If it has a huge defect and just barely fit into both, and there’s a little defect, you’ve got to put a lot of shunt in there so at that point, I would cut the shunt if necessary to 3 to 4 centimeters in the distal artery as well.

That’s one step you’ve got to be careful of because the shunts come rounded on the ends and if you cut it now, you may make a sharp end. So you’ve got to be very cautious that you don’t make it to sharp and you actually cause some internal disruption when putting in the distal artery. If I put it in the distal artery, I’m sorry, I would back bleed this artery to give me brisk back bleeding so I don’t introduce any air to it and I’d put the shunt on into the distal artery and secure that with my best vessel loop as well. So now I’ve got the shunt going from proximally to distally across both vessels with vessel loops holding it in place and presumably no bleeding around that. Then I would secure the shunt in place proximally and distally both. Again, ragged edges on both ends just to save artery. I would take a silk tie , 2-0 or 3-0 silk tie, tie the vessel so that the shunt’s in the vessel, I would tie around the vessel down onto the shunt. And I’m going to take the same suture material and I would tie to the shunt itself just to prevent dislodgement. A lot of times we shunt for orthopedic procedures and they’re moving the arm around or leg around. So I would tie to the vessel and then tie the shunt itself to secure it in place and do the same thing proximally and distally.

Once that shunt is in place I would evaluate distal profusion, is the distal extremity warm and pink? Does it have at least a Doppler flow. I generally can’t feel a pulse distal to a shunt in general. Occasionally you can right next to the shunt but down the distal hand or foot or whatever you can’t usually feel a pulse. But I think obviously viability would be extremity warm, profused, capillary refill, pink, with at least Doppler flow and I would have Doppler available throughout whatever process is going to happen next. If orthopedics is going to fix a bone, I’d have them check the Doppler sequentially. If I’m going to be doing something else, I take in vein from the other extremity, I would have somebody checking the Doppler or myself every 5-10 minutes to make sure that shunt doesn’t go down.

And I think that’s it as far as the shunt.

RC: Okay, let me slip back to the beginning. When you make, what would lead you to make the decision, at what point would you decide that you’re going to use a shunt?

S: Combined vascular orthopedic injuries. Probably the most common situations. Orthopedics has to do some sort of complex boney repair but I also have to do vascular repair. Your options at that point are do your definitive vascular repair and then have orthopedics fix the bone. The pro you establish vascular continuity immediately and the con is when you put your saphenous vein or your PTFE [???] in, ortho then manipulates your extremity around and this may disrupt your repair. So the other option would be to shunt and then have them do their orthopedic repair and then come back afterwards do your definitive repair. So that’s probably the most common situation for me, I’ve got a combined orthopedic vascular injury, I don’t want to do my definitive repair first, so I shunt, let orthopedic do the repair and then I come back, take the shunt out and put a piece of vein or piece of gortex in to fix the artery.

RC: Okay and the reason to do it and let the orthopedic repair go first is?

S: So they don’t disrupt my definitive.

RC: I see so the obstruction would as they’re moving …

S: the bone around

RC: They might then block blood flow.

S: Yes because they’re not paying attention to your vas repair, they’re pretty much the bone and then they move very vigorously.

RC: Okay

S: So that’d be one reason, combine orthopedic vascular trauma. Second reason is a patient who is dying on the table, actively dying, and the time it takes, even a pretty straight forward vascular injury is going to take 20, 30 minutes if everything goes perfectly to reestablish flow and that may not be time that the patient has. As a temporizing measure in a damage control operation and the patient is dying, I would shunt the artery in order to establish fascia flow temporarily, get the patient off the table to the ICU, make him better, warm him up, correct [???acidophilus] and then come back to the operating room in a stage manner 6, 8, 12 hours later to remove the shunt and then do the definitive repair.

I think another option to shunt would be if I wasn’t a trauma surgeon and didn’t have the expertise to do a vascular repair, you know someone’s out in a more rural area and they don’t feel comfortable fixing a femoral artery and they could shunt, which I think a general surgeon, a basic trained general surgeon can do that shut and get the patient to a vascular surgeon or have a vascular surgeon come in. We don’t do that here but I think that another reason to do that.

RC: So they do the final repair, you’d shunt it to get the…or get him stabilized

S: Yes.

RC: When you use the balloon, you do use it, you flush with Heparin and saline, you do that first before you use

S: No, I usually look and see what kind of flow I have first.

RC: And that’s a Doppler decision?

S: No, proximally..

RC: Oh that’s right, you said you just look at blood flow.

S: If it’s proximal it should shoot across the room. If it doesn’t shoot across the room, then I pass a fogarty catheter and I usually base the size, you know, size 3, 4 roughly down there. Probably I don’t know, I usually bring the Fogarties in the room and look at them. It’s easier for me to kind of look at both and see but usually it’s a 3, 4.

So proximally it should shoot across the room. If it does that, then I flush and I’m done. If it doesn’t do that then I pass the Fogarty to get the clot out and again, I should be getting across the room pulsatar [???] flow proximally.

Distally it’s a little more difficult because if they’ve been ischemic for a while they may not have a lot of back flow. I’d like to see some back flow and no matter what I see, I generally pass a fogarty catheter once to make sure I don’t get a lot of clot out. If I see no flow then I pass until I clear all the clot out. It’s a balance because passing catheter gets clot out, but passing catheter also puts the artery in spasm and make cause internal injury, make cause more problems. So I don’t get too crazy distally because I don’t want to have, don’t want to cause secondary injury.

RC: How do you know when you’ve done enough? Getting back flow?

S: I get clot, first of all I get clot back and some back flow.

RC: Okay, if you get no back flow?

S: I generally will pass a Fogarty a couple of times as long as I keep getting clot back. If I pass it once or twice and get no clot back, then I probably won't do any more, I'll just do my repair and then suture the injury.

RC: Okay, I think that's it for that one. When you're tying off the vessel on both sides of the shunt, do you ever use any other equipment to tie it—do you ever use clamps or is that later? There are also clamps that some people use.

S: Clamps I would use to control proximal to see what I'm doing in my repair.

RC: Later you clamp.

S: Yes, I mean you can use the vessel loops or the clamps to control. The clamps are a little bit more secure, they're on, they're not going anywhere. Vessels can come loose or whatever, so the vessels I use for initial control and then I use the clamps for definitive control. But when the shunt is in, I don't usually use clamps in at all. I'll flush and then clamp and then when I put the shunt the clamps will come off.

RC: What leads you to make the decision to trim, you actually trim it to fit.

S: Again, if I've got a bunch of shunt left, I don't want to ram that into a small vessel…

RC: without damaging the vessel

S: Right. So I usually like to have 3 or 4 centimeters of shunt in each side.

RC: Okay, but if there's not a lot of damage that you're dealing with, flow is restricted, then you're going to be trimming the shunt to fit this.

S: Correct to fit whatever..

RC: Whatever centimeter is each side

S: Correct. And the shunts are pretty good. I mean you don't usually get huge defects, usually you're talking about defects between 1 and 3 or 4 centimeters, so the shunt usually actually fits pretty well. But it really depends on the individual patient. I like to have in 3 centimeters proximally and distally.

RC: You said that when you trim the shunt, you have to be really careful about sharp edges when you put them back in. Do you have a way to trim them that takes..

S: I just make sure I cut them square. The shunts come rounded, normally when you get an argyle shunt, it's a straight shunt that comes rounded on the edges. If you cut it, it's no longer rounded. But just make sure that resident cuts it square and there are no sharp edges and if there is, kind of trim that up. But I don't have any technique to do that in particular.

RC: And you use Doppler obviously to detect flow. Have you every done this in a military setting? Are you involved in that?

S: I’m military but have not been to Iraq.

RC: Are you going to?

S: Starting in August. In Iraq, it’ll be the setting I told you about like probably it’s something that I won’t do a definitive repair if I’ve got 8 casualties and I can’t take the time to fix this guys arm, I’ll shunt him, send him to the Army hospital down the road and let them do the definitive repair. Whereas if he was a single casualty and I had unlimited time, I might do the definitive repair. So I have to balance who I would do shunts on. But generally that’s one place where general surgeons have applied it because the military sends general surgeons to do trauma and a lot of them don’t feel comfortable doing a femoral artery repair. And in the Navy there’s no specialists in theatres, no cardiothoracic, no vascular surgeons, in theatre, they’re all Army and Air Force hospitals. So Navy general surgeons do shunt an artery and/or vein to establish flow into the extremity and then send the patient to a vascular surgeon at the next level of care.

RC: Let’s see, equipment, I think I heard most of the equipment. We talked about clamps, you wouldn’t use clamps in this case but only when you did the final repair, so you’ve got to clamp off the artery, that’s clear. Anything else we didn’t talk about in terms of the equipment?

S: You mean you need vessel loops, vascular clamps of some sort, obviously silk suture, Fogarty catheters, Heparin salines, systemic Heparin if you make that decision to use that.

RC: That it? Ken?

K: In the very beginning, you seemed to imply that it made a difference…are there decisions to be made when you first examined?

S: Yes, the difference is in the stab wound, it may be something, for a gunshot wound generally I would not pull it, do a primary repair, I’m going to put something in between the injury, a piece of saphenous vein or a piece of gortex because a gunshot wound would certainly cause enough destruction to the, you know, either separation of vessel, destruction of the vessel, sometimes there will be too much tension to pull together. However if it’s a stab wound that just cleanly cuts an artery in half, I would be able to pull it together as a primary repair and I wouldn’t shunt that patient at all. So the stab wound I just do a primary repair and even if it was damage control, it’s fast enough to do right away. If it’s a combine orthopedic vascular, which is unlikely in a stab wound, you can do that very quickly and I would feel pretty comfortable with that repair. So generally it would be more of a decision as to how I’m going to fix the vessel definitively.

Now if someone, if I was doing a damage control and maybe I might shunt the stab wound but in general I would probably just pull that together primarily. That’s kind of the main reason.

RC: You’d pull the two ends together and do a temporary.

K: In a damage similar to a gunshot, how’s this?

S: Worse if anything.

RC: How much of an artery has to be damaged for you to think about amputating? What makes that decision?

S: Extremity amputation?

RC: Yes.

S: Not so much the damage to the artery as systemic condition of the patient.

RC: How long it’s been since…

S: How long, how sick the patient is and how damaged the rest of the extremity is. The vessel itself no matter how damaged that is, I try to fix that. But if he’s got the vessel plus a venous injury plus a destroyed extremity from a boney standpoint, nerve standpoint that would make my decision to amputate. But the vessel itself doesn’t matter how damaged it is, we can always do something to fix that.

RC: All right.

K: In the tools area, you mentioned using clamps, is the kind of clamp important?

RC: He only uses clamps for, well at least, for control.

S: Usually we’ll have either clamped or sometimes it just depends on how easy it is to get out. If it’s easy to get out, you may just hold it with a pick up and control it; sometimes we put a clamp on but it just needs to be a vascular clamp, you know sort of non crushing clamp and the size fits whatever, you know bulldog clamps work easily in your field because they’re small. But you can use an angled DeBakey clamp and any kind of vascular clamp is fine as long as it’s vascular and the right size.

K: The final question I have is that if the patient is going to be traveling, how’s your decision to?

S: That’s when tying it to the vessel and to the shunt, kind of like you would tie a chest tube down or abdominal drain and you tie it to the vessel and the shunt, that way the shunt doesn’t move at all within the vessel.

K: Would you do it differently if you know that patient’s going to be traveling?

S: I just do that way all the time. But I think some people would just tie to the vessel alone on both ends and not tie it to the shunt. That would secure fine if you not moving any where, that would be fine. But I’ve just gotten in the habit of tying it to both the vessel and the shunt just out of habit.

RC: Okay, that’s it. Now here’s what we’re going to do next. First of all, we’re going to have the interview typed up and then out of that we’re going to create procedure, one, two, three, four and organize some of your [???] we’re doing now. We’ll ask you to review it, we’ll give to you on paper, but we’ll also give it to you [???]. We’ll meet with you for the actual writing. Then we’re going to revise it, then we’re going to actually show you one or two other protocols that other surgeons have done. We’re trying to arrive at one best protocol. It’s an Army project by the way and we’re funded by the Army to do this. Obviously, maybe surgeons are doing this and some surgeons aren’t. But we’re trying to get as many protocols as we can with the idea that we come up with the best given the conditions. We’re going to ask you to help us not only by revising your own but by editing other people’s work.

S: Sure, that’s be great.

RC: Dynamite. And then we’re going to have a publication when we’re done and we hope you’ll join us in co-authoring.

S: Absolutely, great.

RC: Thank you.

S: It’s so nice to meet you both.

RC: Thanks for your time.

STOP-END

APPENDIX C:

Procedure for the Use of a Shunt for Lower Extremity Vascular Disruption

Gold Standard Protocol

Cognitive Task Analysis:
Surgical use of Argyle shunt for lower extremity
Vascular disruption

Task Analyst: Richard Clark, Ed.D.
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Objective:
- Restore blood flow in Forward Surgical Team (FST) setting when vascular injury to thigh has significantly reduced or eliminated flow to lower extremity and threatens life or limb
- To temporize while a fracture is being repaired or as part of damage control
- To achieve proximal and distal control of the artery in order to identify, delineate, and repair an injury

Conditions:
Indications:
- Penetrating arterial or venous injury to lower extremity
- Uncontrolled hemorrhaging from the injury and/or
- Reduced or no pulse distal to injury and/or
- Absence of Doppler signal
- Limb is cool below injury and warm above
- And/ABI is less than .8
- Or/Transfer time to CASH and/or CASH load would risk patient life or limb
- Or/ advanced or progressive shock (tachycardia with decreased blood pressure) with uncontrolled hemorrhage
- A Pt that is hemodynamically unstable or coagulopathic, acidotic and hypothermic with temp less than 32 centigrade; or with multiple other life threatening injuries requiring repair
- Temporary vessel repair prior to fracture fixation in cases with both a vascular and skeletal injury
- Unavailability of vascular expertise to repair the vessel
- Unavailability of instruments or equipment to repair the vessel
- Injury is too complex for immediate repair
- Damage to or segmental loss of the vessel
- A salvageable limb

Contraindications:

- Injury is so severe shunt will not establish flow and amputation indicated by the presence of rigor mortise in extremity
- CASH transfer time and medical staff availability is adequate for Pt treatment?
- Ample time to perform definitive repair
- In combination with a ER thoracotomy
- Acidosis is too high indicated when Ph is less than 7.1
- Nerve is transected
- Damage to a small end artery
- Pt is so unstable that time does not permit shunting and extremity requires amputation to save life

Standard:

- Time: approximately 15 minutes plus time to locate damaged vessel
- An extremity that is:
    - Warm
    - Perfused
    - Capillary refill
    - Pink
    - Has a flow detectable by Doppler

Equipment:

- Surgical tray (scalpels, retractors, etc.)
- Assortment of shunts (Argyle, Chapman, French)
- Assortment of Fogarty catheters;
- Vessel loops
- Vascular clamps
- Doppler
- Blood pressure cuff
- Small caliber chest tubes for certain vessels
- Suture and O-silk
- Heparin
- Angiography equipment
- Umbilical tape
- X-ray

Task List:

1. Assess injury and decide whether blood flow control needs to be reestablished
2. If reduced flow threatens patient life or limb, surgically assess injury and determine treatment
3. Prepare site of injury, insert Argyle shunt and check for additional injuries
4. Communicate FST treatment for CASH surgical team and arrange Pt transport to CASH

Task 1: Assess lower extremity injury and decide whether blood flow control needs to be reestablished

Step 1.1 Conduct standard assessment of extent of Pt injury and current condition

Step 1.2: Assess blood flow distal to injury with palpation and Doppler

IF palpated femoral pulse in groin is strong and pulse distal to injury is strong and no other significant injury, and there is no evidence of uncontrolled hemorrhage with an absence of signs of hemorrhagic shock, THEN go to Task 4 and transport Pt to CASH

IF distal palpated pulse is weak, THEN check ABI
IF ABI is less than .8, THEN go to Step 1.4

IF there is no distal pulse and the distal area is cold and there is uncontrolled hemorrhage, THEN go to Task 2

Step 1.3: Use ultrasound to assess blood flow distal to injury

IF ultrasound picture indicates limited or no flow, or picture is unclear go to Step 1.4

Step 1.4: Decide whether to send Pt to CASH or treat in FST

IF transport time to CASH is excessive or uncertain and if transported, Pt might experience threat to life or limb, THEN treat at FST and go to Task 2

Standard is "Do not treat in FST unless necessary to preserve life or limb"

IF injury does not obviously threaten life or limb and availability of surgeon in CASH and/or transportation time to CASH seems not to threaten Pt life or limb, go to Task 4 (transportation)

Task 2: If reduced flow threatens patient life or limb, assess injury and determine required treatment

Step 2.1: Determine bone injury and stabilize bone if possible

IF a significant unstable bony injury is found and surgeon can stabilize in reasonable amount of time (+/- 10 minutes), THEN stabilize bone quickly to protect the vascular procedure

Step 2.2: Expose zone of injury to identify specific vascular injury

Step 2.3: Decide the order in which to place the shunt(s)

IF, there is a combined arterial and venous injury, THEN shunt the vein and then shunt the artery

IF, there is an injury to the artery or the vein only, THEN shunt only the injured artery or vein

Step 2.4: Determine location to control hemorrhage

IF there is uncontrolled hemorrhage or maximum control of blood flow is desired, THEN expose femoral artery at a more proximal site or at the groin and control blood flow using bulldog clamps, and ligate.

IF the damaged vessel cannot be located visually, THEN perform an angiography to locate damaged vessel

Step 2.5: Expose injured segment of artery,

IF exposure indicates

- Partial thickness injury to Intima or
- Segmental disruption or
- Incomplete or partial disruption or
- Intact adventitial layer with disruption or delamination of the internal layers

THEN Doppler directly on artery

IF Doppler indicates flow decreases and stops THEN assume lack of blood flow and go to Step 2.6

IF Doppler indicates flow does not decrease, THEN END and observe the PT

Step 2.6: Control hemorrhage digitally with compression of the finger or hand

Step 2.7: Place Bulldog clamps on artery above and below injury

[AND/OR] Place vessel loops around the artery encircling them twice

Step 2.8: Pull up on proximal and distal vessel loops, remove finger, and examine

IF blood flow has stopped, THEN go to Task 3

IF blood flow has not stopped, THEN re-evaluate clamps and search for additional side branches

Step 2.9: Assess the need for possible distal fasciotomy

Task 3: Prepare site of injury and insert Argyle shunt

Step 3.1: Identify, isolate and prepare non-viable portion of artery

IF partial thickness injury, THEN use Iris scissors and remove damaged segment, clean up edges of artery so that all levels are even and go to Step 3.2

IF severed artery, THEN clean up edges with Iris scissors to insure that Intima is even with other artery levels and go to Step 3.2

Step 3.2: Pass two loops of large gauge (#2 to #4) ligatures around artery approximately 2 cm above and two loops the same distance below cut to ligate.

Step 3.3: Perform a Fogarty embolization of the extremity

IF, after catheterization, vessel is not clear with good back bleeding, THEN perform an angiography

IF, after repeated catheterization after angiography, vessel is not clear with good back bleeding, THEN perform an X-ray

IF thrombosis indicated, THEN use Fogartey catheter with saline balloon dilator to pull out thrombosis 8 to 10 cm proximally and then flush vessel with Heparin. Repeat distally and go to Step 3.4.

IF no thrombosis, go to Step 3.4

Step 3.4: Size vessel diameter and measure length of required shunt and THEN select longest and widest, Argyle shunt possible to accommodate blood flow and limb movement during transportation to CASH

Step 3.4A: Decide if there are shunts available that match the vessel damage

IF there is a match between the width and length of the damage gap to the vessel and an available shunt, THEN go to Task 3.5

IF the shunt length exceeds the damage gap to the vessel, THEN go to Step 3.4B

Step 3.4B: Decide to loop or cut the shunt

It is an option to loop the shunt but would prefer to trim length to bridge gap.

Standard: The ends must be cut square with no sharp edges, to avoid internal disruption as it is placed in the distal artery and a length that will extend about 2-3 cm into each end of the native vessel

Step 3.5: Irrigate shunt with heparinize saline solution, open the bulldog clamp on one end, insert Argyle shunt into vessel proximally or distally and close clamp over end of shunt. Repeat at opposite end of vessel.

Step 3.6: Decide to use Heparin

IF the wound is isolated, THEN use 5000 units of Heparin systemically

IF the wound is not isolated, THEN do not use Heparin, and go to Step 3.7

Step 3.7: Release all clamps (and/or vessel loops) and check for blood flow by palpating pulse digitally or by Doppler

IF blood flow is adequate by palpating digitally, THEN suture proximal and distal ligatures to secure shunt AND secure the middle part of the shunt with a tether AND go to step 3.8

Standard: Secure the shunt with o-silk as close to the end of the distal end of the vessel as possible to preserve uninjured vessel length OR 2-5mm away from the shunt and with a single throw

IF blood flow is inadequate, THEN go to Step 1.2 and use Doppler to check again for additional distal injury and repeat procedure to this point. Examine carefully to insure that no other injury exists

Standard: No palpatable pulse, and/or the foot is cold and white

Perform an angiography

Step 3.8: Palpate for compartment syndrome

IF compartment syndrome found or IF time to transport Pt to CASH is issue, open compartment linings surgically

Whether flow improves or not, provided that flow is restored to key areas of leg, go to Task 4 and transport to CASH

Task 4: Communicate FST treatment record to CASH surgical team and arrange Pt transport to CASH

Goal: Use every means to insure that accurate and complete information about injury and FST treatment reaches CASH treatment team with Pt. Paperwork is sometimes lost and radio communication with CASH is sometimes interrupted so as many backup records should be made available as is possible.

Conditions:
FST team has provided all immediate treatment required to preserve life and limb
While Pt may need much more care, CASH is best context for next level of treatment.

Step 4.1: Complete Patient Care Notes and attach securely to Pt so propeller wash from helicopter does not blow away.

Step 4.2: If available, radio CASH to provide verbal description of Pt name, evaluation, treatment and needs when Pt arrives at CASH – empathize shunt placement and time since injury

Step 4.3: Repeat information given in 4.2 to Medics accompanying Pt to CASH and instruct them to relay to CASH

Step 4.4: If possible, burn PC based CD of x-ray's, and clinical data notes and place CD on Pt

Step 4.5: If possible, put wide band of tape securely across dressing and with indelible marker, write Pt name, the time injury occurred, diagnosis, FST treatment and Pt needs.

End

APPENDIX D:

Scheme for Coding Surgeons' Interview Transcripts

Category	Type	Code
Objective/Goal		
	Action	OA
	Conditions	OC
	Standards Time Accuracy	 OST OSA
Steps		
	Action	A
	Decision Alternative Criteria	 DSA DSC
Declarative Knowledge		
	Concept	DC
	Process	DPR
	Principle	DPN
Other		
	Reasons	R
	Equipment & Materials	EM
	Sensory Cues Hearing Seeing Touching	 SH SS ST